

$$D1 = D \times \left( 1 - \frac{Z1}{100} \right)$$

**§ 90.326 Pre- and post-test analyzer calibration.**

Calibrate the range of each analyzer used during the engine exhaust emission test prior to and after each test in accordance with the following:

- (a) Make the calibration by using a zero gas and a span gas. The span gas value must be between 75 percent and 100 percent of full scale, inclusive, of the measuring range.
- (b) Use the same analyzer(s) flow rate and pressure as that used during exhaust emission test sampling.
- (c) Warm-up and stabilize the analyzer(s) before the calibration is made.
- (d) If necessary clean and/or replace filter elements before calibration is made.
- (e) Calibrate analyzer(s) as follows:
  - (1) Zero the analyzer using the appropriate zero gas. Adjust analyzer zero if necessary. Zero reading should be stable.
  - (2) Span the analyzer using the appropriate span gas for the range being calibrated. Adjust the analyzer to the calibration set point if necessary.
  - (3) Re-check zero and span set points.
  - (4) If the response of the zero gas or span gas differs more than one percent of full scale, then repeat paragraphs (e) (1) through (3) of this section.

**§ 90.327 Sampling system requirements.**

(a) *Sample component surface temperature.* For sampling systems which use heated components, use engineering judgment to locate the coolest portion of each component (pump, sample line section, filters, and so forth) in the heated portion of the sampling system that has a separate source of power or heating element. Monitor the temperature at that location. If several components are within an oven, then only the surface temperature of the component with the largest thermal mass and the oven temperature need be measured.

(b) If water is removed by condensation, monitor the sample gas temperature or sample dew point either within

the water trap or downstream. It may not exceed 7° C.

**§ 90.328 Measurement equipment accuracy/calibration frequency table.**

- (a) The accuracy of measurements must be such that the maximum tolerances shown in Table 2 in Appendix A of this subpart are not exceeded.
- (b) All equipment and analyzers must be calibrated according to the frequencies shown in Table 2 in Appendix A of this subpart.
- (c) Prior to initial use and after major repairs, bench check each analyzer (see § 90.323).
- (d) Calibrate equipment as specified in § 90.306 and §§ 90.315 through 90.322.
- (e) At least monthly, or after any maintenance which could alter calibration, perform the following calibrations and checks.
  - (1) Leak check the vacuum side of the system (see § 90.324(a)).
  - (2) Verify that the automatic data collection system (if used) meets the requirements found in Table 2 in Appendix A of this subpart.
  - (3) Check the fuel flow measurement instrument to insure that the specifications in Table 2 in Appendix A of this subpart are met.
- (f) Verify that all NDIR analyzers meet the water rejection ratio and the CO<sub>2</sub> rejection ratio as specified in § 90.325.
- (g) Verify that the dynamometer test stand and power output instrumentation meet the specifications in Table 2 in Appendix A of this subpart.

**§ 90.329 Catalyst thermal stress test.**

(a) *Oven characteristics.* The oven used for thermally stressing the test catalyst must be capable of maintaining a temperature of 500° C ± 5° C and 1000° C ± 10° C.

(b) *Evaluation gas composition.* (1) A synthetic exhaust gas mixture is used for evaluating the effect of thermal stress on catalyst conversion efficiency.

(2) The synthetic exhaust gas mixture must have the following composition:

Constituent	Volume percent	Parts per million
Carbon Monoxide .....	1	.....

Constituent	Volume percent	Parts per million	Constituent	Volume percent	Parts per million
Oxygen .....	1.3	.....	Nitrogen = Balance		
Carbon Dioxide .....	3.8	.....	* Propylene/propane ratio = 2/1.		
Water Vapor .....	10	.....	APPENDIX A TO SUBPART D OF PART 90—		
Sulfur dioxide .....		20	TABLES		
Oxides of nitrogen .....		280			
Hydrogen .....		3500			
Hydrocarbon* .....		4000			

TABLE 1.—SYMBOLS USED IN SUBPART D

Symbol	Term	Unit
CO	Carbon monoxide.	
CO <sub>2</sub>	Carbon dioxide.	
NO	Nitric oxide.	
NO <sub>2</sub>	Nitrogen dioxide.	
NO <sub>x</sub>	Oxides of nitrogen.	
O <sub>2</sub>	Oxygen.	
conc	Concentration (ppm by volume) .....	ppm
f	Engine specific parameter considering atmospheric conditions.	
F <sub>FCB</sub>	Fuel specific factor for the carbon balance calculation.	
F <sub>FD</sub>	Fuel specific factor for exhaust flow calculation on dry basis.	
F <sub>FH</sub>	Fuel specific factor representing the hydrogen to carbon ratio.	
F <sub>FW</sub>	Fuel specific factor for exhaust flow calculation on wet basis.	
G <sub>AIRW</sub>	Intake air mass flow rate on wet basis .....	kg/h
G <sub>AIRD</sub>	Intake air mass flow rate on dry basis .....	kg/h
G <sub>EXHW</sub>	Exhaust gas mass flow rate on wet basis .....	kg/h
G <sub>Fuel</sub>	Fuel mass flow rate .....	kg/h
H	Absolute humidity (water content related to dry air) .....	gr/kg
i	Subscript denoting an individual mode.	
K <sub>H</sub>	Humidity correction factor.	
L	Percent torque related to maximum torque for the test mode .....	percent
mass	Pollutant mass flow .....	g/h
n <sub>d,i</sub>	Engine speed (average at the i'th mode during the cycle) .....	1/min
P <sub>s</sub>	Dry atmospheric pressure .....	kPa
P <sub>a</sub>	Test ambient saturation vapor pressure at ambient temperature .....	kPa
P	Gross power output uncorrected .....	kW
P <sub>AUX</sub>	Declared total power absorbed by auxiliaries fitted for the test .....	kW
P <sub>M</sub>	Maximum power measured at the test speed under test conditions .....	kW
P <sub>i</sub>	$P_i = P_{M,i} + P_{AUX, i}$	
P <sub>B</sub>	Total barometric pressure (average of the pre-test and post-test values) .....	kPa
R <sub>a</sub>	Relative humidity of the ambient air .....	percent
T	Absolute temperature at air inlet .....	C
T <sub>be</sub>	Air temperature after the charge air cooler (if applicable) (average) .....	C
T <sub>clout</sub>	Coolant temperature outlet (average) .....	C
T <sub>dp</sub>	Absolute dew point temperature .....	C
T <sub>d,i</sub>	Torque (average at the i'th mode during the cycle) .....	N-m
T <sub>SC</sub>	Temperature of the intercooled air .....	C
T <sub>ref</sub>	Reference temperature .....	C
V <sub>EXHD</sub>	Exhaust gas volume flow rate on dry basis .....	m <sup>3</sup> /h
V <sub>AIRW</sub>	Intake air volume flow rate on wet basis .....	m <sup>3</sup> /h
P <sub>B</sub>	Total barometric pressure .....	kPa
V <sub>EXHW</sub>	Exhaust gas volume flow rate on wet basis .....	m <sup>3</sup> /h
WF	Weighing factor.	
WF <sub>E</sub>	Effective weighing factor.	

TABLE 2.—MEASUREMENT CALIBRATION ACCURACY AND FREQUENCY

No.	Item	Permissible deviation from reading *		Calibration frequency
		Non-idle	Idle	
1	Engine speed	± 2 %	Same	Monthly or within one month prior to the certification test.
2	Torque	± 2 %	± 5 %	Monthly or within one month prior to the certification test.
3	Fuel consumption	± 2 %	± 5 %	Monthly or within one month prior to the certification test.
4	Air consumption	± 2 %	± 5 %	As required.
5	Coolant temperature	± 2° C	Same	As required.
6	Lubricant temperature	± 2° C	Same	As required.
7	Exhaust back pressure	± 5 %	Same	As required.
8	Inlet depression	± 5 %	Same	As required.
9	Exhaust gas temperature	± 15° C	Same	As required.
10	Air inlet temperature (combustion air)	± 2° C	Same	As required.
11	Atmospheric pressure	± 0.5 %	Same	As required.
12	Humidity (combustion air) (relative)	± 3.0 %	Same	As required.
13	Fuel temperature	± 2° C	Same	As required.
14	Temperature with regard to dilution system	± 2° C	Same	As required.
15	Dilution air humidity	± 3 % absolute	Same	As required.
16	HC analyzer	± 2 % *	Same	Monthly or within one month prior to the certification test.
17	CO analyzer	± 2 % **	Same	Monthly or within one month prior to the certification test.
18	NO <sub>x</sub> analyzer	± 2 % **	Same	Monthly or within one month prior to the certification test.
19	NO <sub>x</sub> converter check	90 %	Same	Monthly or within one month prior to the certification test.
20	CO <sub>2</sub> analyzer	± 2 % **	Same	Monthly or within one month prior to the certification test.

\*All accuracy requirements pertain to the final recorded value which is inclusive of the data acquisition system.

\*\*If reading is under 100 ppm then the accuracy shall be ± 2 ppm.

TABLE 3.—TEST FUEL SPECIFICATIONS

Item	Property	Tolerances	Procedure (ASTM) <sup>1</sup>
Sulfur, ppm max. ....	339 .....	.....	D 2622–92
Benzene, max. % .....	1.5 .....	.....	D 3606–92
RVP, psi .....	8.7 .....	±0.2 .....	D 5191–93a
Octane, R+M/2 .....	87.3 .....	±0.5 .....	D 2699–92
			D 2700–92
IBP, ° C .....	32.8 .....	±11.0 .....	D 86–93
10 % point, ° C .....	53.3 .....	±5.5 .....	D 86–93
50 % point, ° C .....	103.3 .....	±5.5 .....	D 86–93
90 % point, ° C .....	165.6 .....	±5.5 .....	D 86–93
End Point, max. ° C .....	212.8 .....	.....	D 86–93
Phosphorus, g/liter, max. ....	0.02 .....	.....	D 3231–89
Lead, g/liter, max. ....	0.02 .....	.....	
Manganese, g/liter, max. ....	0.004 .....	.....	
Aromatics, % .....	32.0 .....	±4.0 .....	D 1319–89
Olefins, % .....	9.2 .....	±4.0 .....	D 1319–89
Saturates, % .....	Remainder .....	.....	D 1319–89

<sup>1</sup> All ASTM procedures in this table have been incorporated by reference. See § 90.7.

## APPENDIX B TO SUBPART D—FIGURES

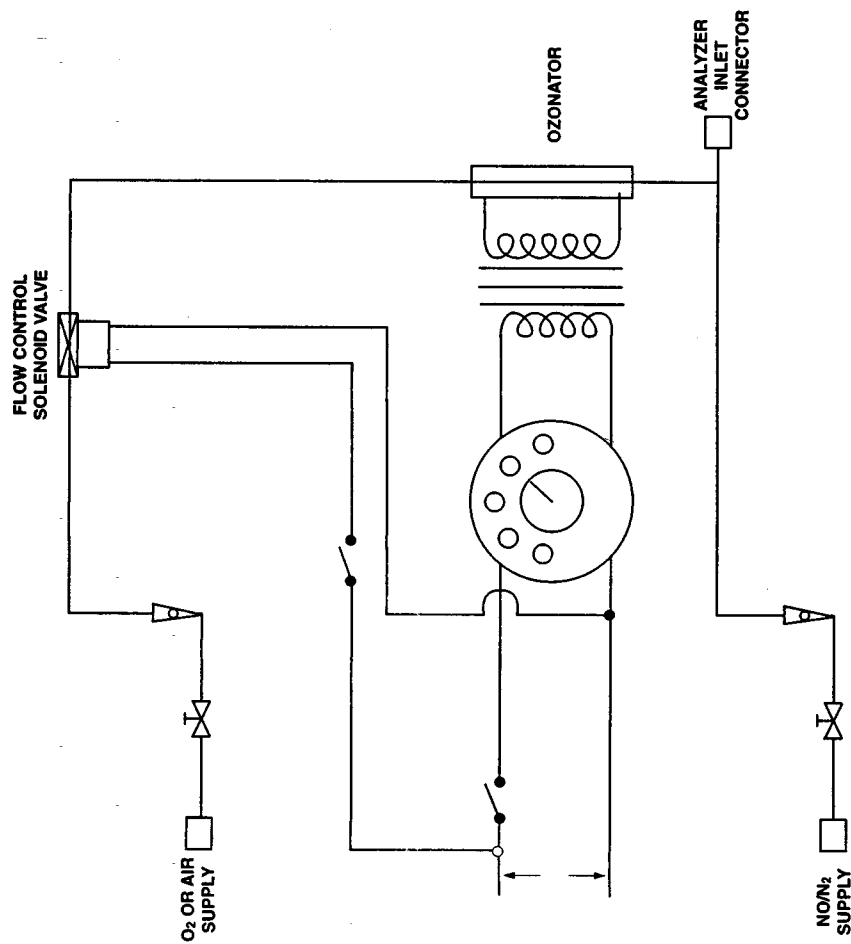
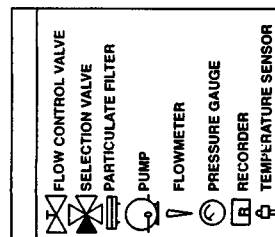


Figure 1. — NOx Converter Efficiency Detector



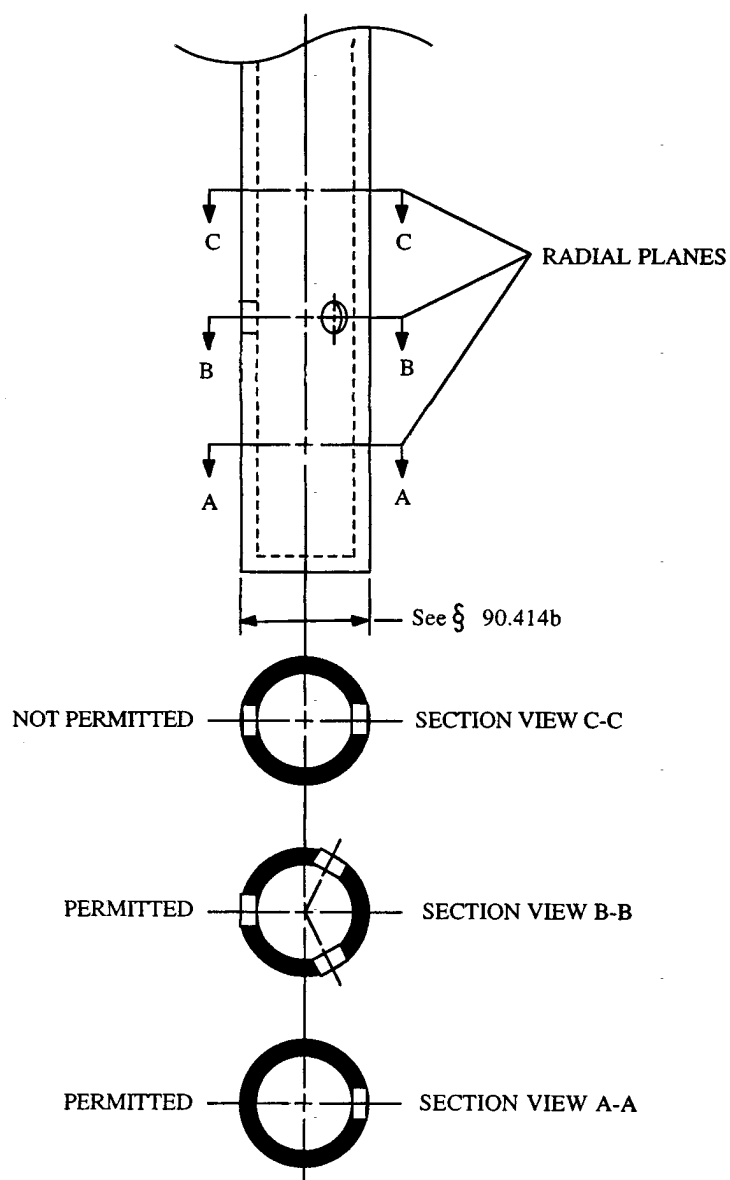


Figure 2.--Sample Probe and Typical Hole Spacings

## Subpart E—Gaseous Exhaust Test Procedures

### § 90.401 Applicability.

(a) This subpart describes the procedures to follow in order to perform exhaust emission tests on new nonroad spark-ignition engines and vehicles subject to the provisions of subpart A of part 90. Provisions specific to raw gas sampling are in § 90.414 through § 90.419, provisions specific to constant volume sampling are in § 90.420 through § 90.426. All other sections in this subpart apply to both raw gas sampling and constant volume sampling except where indicated otherwise.

(b) Requirements for emission test equipment and calibrating this equipment are found in subpart D of this part.

### § 90.402 Definitions.

The definitions in § 90.3, § 90.101, and § 90.302 apply to this subpart.

### § 90.403 Symbols, acronyms, and abbreviations.

(a) The acronyms and abbreviations in § 90.5 apply to this subpart.

(b) The symbols in Table 1 in Appendix A to Subpart D apply to this subpart.

### § 90.404 Test procedure overview.

(a) The test consists of prescribed sequences of engine operating conditions to be conducted on an engine dynamometer or equivalent load and speed measurement device. The exhaust gases generated during engine operation are sampled either raw or dilute and specific components are analyzed through the analytical system.

(b) The test is designed to determine the brake-specific emissions of hydrocarbons, carbon monoxide, carbon dioxide, and oxides of nitrogen and fuel consumption. The test consists of three different test cycles which are application specific for engines which span the typical operating range of nonroad spark-ignition engines. Two cycles exist for Class I and II engines and one is for Class III, IV, and V engines (see § 90.103(a) and § 90.116(b) for the definitions of Class I–V engines). The test cycles for Class I and II engines consist of one idle mode and five power modes

at one speed (rated or intermediate). The test cycle for Class III, IV, and V engines consists of one idle mode at idle speed and one power mode at rated speed. These procedures require the determination of the concentration of each pollutant, fuel flow, and the power output during each mode. The measured values are weighted and used to calculate the grams of each pollutant emitted per brake kilowatt hour (g/kW-hr).

(c)(1) When an engine is tested for exhaust emissions the complete engine must be tested, with all emission control devices installed and functioning.

(2) On air cooled engines, the cooling fan must be installed. For engines whose cooling fan serves a dual purpose, such as an air pump/blower, an external fan may be used to provide the engine with cooling air and the original cooling fan may be removed.

(d) All emission control systems installed on or incorporated in the application must be functioning during all procedures in this subpart. In case of component malfunction or failure, no maintenance is allowed without prior approval from the Administrator, in accordance with § 90.119.

### § 90.405 Recorded information.

(a) Record the information described in this section for each test, where applicable.

(b) *Test data; general.* (1) Engine identification number.

(2) Engine emission control system.

(3) Test operator(s).

(4) Number of hours of operation accumulated on the engine prior to beginning the warm-up portion of the test (to the nearest tenth hour).

(5) Fuel identification.

(6) For 2-stroke engines, fuel/oil mixture ratio.

(7) Date of most recent analyzer bench calibration.

(8) All pertinent instrument information such as tuning, gain, serial numbers, detector number, and calibration curve(s). As long as this information is traceable, it may be summarized by system number or analyzer identification numbers.

(c) *Test data; pre-test.* (1) Date and time of day.

(2) Test number.